were still productive of such marvellous results at the hands of the eminent professors elected by the institution. He therefore gladly embraced the opportunity which recently presented itself of acquiring the commodious house immediately adjoining the Royal Institution, and submitted a scheme to its managers, which met with their fullest sympathy and which they readily accepted with unanimity. Work was immediately commenced to alter the building so as to make it suitable for its new purpose, and, thanks to the advice which had been freely extended to him by scientific men all over the world, and the active co-operation of Lord Rayleigh and Prof. Dewar, of the architect, Mr. Flockhart, and of his son, Mr. Robert Mond, to whom he left the selection of the apparatus and the equipment of the place generally, the laboratory which they asked his Royal Highness to inaugurate that day would stand favourable comparison with any other laboratory in or out of England as to the completeness and convenience of its appliances, and was provided with the best instruments made at the present day. It was unique of its kind, being the only public laboratory in the world solely devoted to research in pure science. In order to insure its continued usefulness he had endowed it so as to cover the cost of maintenance of the fabric and all necessary current expenses. He named it the Davy-Faraday Research Laboratory in perpetual memory of those two great pioneers of science who carried out their world-famed and epoch-making researches almost on that spot, and whose example he hoped would stimulate and inspire every one who came to work under that roof. It was a source of very great gratification to him that the eminent successors of those great men, Lord Rayleigh and Prof. Dewar, had consented to undertake the duties of directors of the laboratory, and this gratification had been the greater because those gentlemen made it a condition of their acceptance of the post that it should be without emolument. An experienced superintendent had been appointed in the person of Dr. Scott, and nothing was now wanting for its success but a number of investigators competent and ardent to continue the great work of this century, the unravelling of the secrets of nature. As soon as his Royal Highness had declared the building open, persons of either sex or any nationality would be welcome within its walls who could satisfy the laboratory committee that they were fully qualified to undertake original scientific research in pure and physical chemistry, and preference would naturally be given to those who had already published original work. If this country had distinguished itself in one way more than another in that glorious rivalry with other nations for extending our knowledge of natural phenomena and our power over the forces of nature it had been by the large number of contributors to our knowledge, who on the continent would be called amateurs in science—men who devoted their lives to the study and advancement of science from pure love for the subject. He need only instance the names of Cavendish, Joule, and Darwin to say that they included men of the very highest rank. In giving this laboratory to the English nation he had done so in the firm conviction that this country would continue to bring forth in the future, as it had done in the past, men of the same rank and of the same devotion to science for its own sake, and it was a fond hope of his that such men would find there all the facilities and all the necessary appliances for carrying out their researches. The further we advanced in the study of nature the more accurate and elaborate was the apparatus required, and the more difficult it became to carry on delicate work in a private laboratory. He had placed that laboratory in the centre of London because he believed that this great city would continue to be the intellectual centre of the civilised world, where the brightest minds would congregate. He had intrusted it to the Royal Institution so as to insure its being open to men and women of all schools and of all views on scientific questions. It had given him great pleasure that in establishing the Davy-Faraday Laboratory, he had been able at the same time to enlarge the old laboratories of the Royal Institution, and also to make additions to its library and reception rooms, which he hoped would prove a convenience to its members. He looked upon that laboratory as an important step forward in that great movement for the advancement of scientific research in this country, to which his Royal Highness's revered and illustrious father gave so powerful an impulse, and which has been so distinguished a feature of the many-sided and unparalleled progress made by this nation during the glorious reign of his mother, her Majesty the Queen. It was a source of specially great satisfaction to him that his Royal Highness deemed that laboratory worthy to be opened by himself, and he humbly thanked his Royal Highness for having come there that day. His presence on that occasion would certainly add very greatly to the success of the Davy-Faraday Research Laboratory of the Royal Institution.

The Prince of Wales in reply said :—Prof. Mond, it affords me much satisfaction to assist at the opening of the series of beautifully-arranged and well-equipped research laboratories which this country owes to your generosity, and I congratulate the members of the Royal Institution of Great Britain upon this most important accession to the resources which have been placed at the command of the institution for the advancement of chemical and physical science. The Royal Institution has long enjoyed a world-wide reputation, thanks to the marvellous work of the succession of illustrious men whose researches, carried on within these walls, have very largely contributed to secure and maintain for this country a foremost position as a source of great discoveries and important advances in science and its applications. The identification of the laboratories which you have founded with the names of two of the most eminent of former professors of the Royal Institution and of English men of science—Humphry Davy and Michael Faraday—is a graceful act on your part. The fact that the present distinguished professors of physics and chemistry, Lord Rayleigh and Prof. Dewar, have undertaken the important duties of directors of the new research laboratories without any remuneration must afford most gratifying evidence to you of the great faith entertained by them in the benefit to the promotion of science which your wisely-applied munificence is destined to realise.

THE BACTERIA WHICH WE BREATHE, EAT, AND DRINK.[1]

THE surface of the earth is inhabited by bacteria : wherever there is dead organic matter, wherever there are human or animal excreta, wherever decomposition is going on, in stagnating or in flowing water, within our houses and without, bacteria collect. They are so widely distributed that practically everywhere we are surrounded by these minute vegetable cells. From the bacteriological standpoint we live amongst decomposing matter. Without bacteria there is no decomposition or putrefaction ; they reduce the organic matter to "dust," and with the atomised matter they are again carried away by air or water. Dust is laden with bacteria, and since a great part of dust is derived from decomposing matter, it follows that, although we do not realise it, we are living in an atmosphere of decomposition.

The air which we breathe, therefore, contains bacteria. These vary in amount with certain conditions. If the air is calm their number diminishes, but if there is wind or draught, they may be present in enormous numbers. Again, in the open country air there are, other things being equal, considerably less micro-organisms than in the dusty streets of London. Thus there is an extraordinary difference between the air in Oxford Street and on Wandsworth Common.

The air may be roughly tested by coating sterile plates of glass with gelatine, and exposing them for a given time in the locality which we wish to examine. The bacteria will fall on the surface of the gelatine, and on incubation at a suitable temperature they will develop into visible colonies which can be readily counted. The number of colonies is a fair, though not an absolute, index of the bacterial purity or impurity of the air. The more colonies we find on the surface of the gelatine, the more bacteria, of course, the air must have contained. A plate exposed in Oxford Street would be covered with colonies, while a plate exposed on Wandsworth Common would show only a few. This is, of course, only a rough-and-ready method which cannot be used for accurate work, but, nevertheless, it gives us good comparative results.

The lantern slides exhibited on the screen demonstrate to you that the air which we breathe always contains micro-organisms, and that therefore we are always inhaling bacteria. Many organisms are incapable of growing at the temperature of the body ; they require a lower temperature. Such organisms, we may assume, cannot thrive in the body of the warm-blooded animal, and are therefore, probably, of little importance so far as we are concerned. Keeping this in view, I have always incubated my plates coated with agar-agar at the body temperature, in order to gain information as to the approximate number of organisms which are likely to find access to our respiratory tract, and which have a chance of thriving there. I have not attempted to separate the aerobic organisms from the anaerobic ones, *i.e.* those which can grow in the presence of oxygen from those which cannot. All I wish to show is that under ordinary conditions of life we must breathe an air which contains bacteria, sometimes many bacteria. These plates do not tell us how many bacteria we inhale in a given time; they simply tell us that the air which we breathe is not sterile.

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[1] A lecture delivered at the London Institution, by Dr. A. A. Kanthack, Lecturer on Pathology, St. Bartholomew's Hospital.

The bacterial flora of air varies considerably. The lady shopping in Oxford Street will inhale more bacteria than the boy who runs about on Wandsworth Common.

We all expect to find that the air in a railway carriage of the Underground Railway is full of bacteria; but, although very rich in bacteria, it is not so impure as might have been anticipated.

I have prepared a number of plates from the air in my laboratory, exposing them from one to five minutes. Some of them are very full of colonies, others less; and this depends on the number of students that have been at work during that time. The more students the more dust, and therefore the more bacteria.

Wherever many people are congregated the air becomes laden with dust and bacteria. Thus plates exposed in the Surgery of one of our largest general hospitals for three to five minutes are covered with numerous colonies. Compare this with the air in the quadrangle of the same hospital, and you will see the effect of confinement and of crowding together. In the former case we find numerous colonies, while in the latter case—*i.e.* in the quadrangle—the air is much freer from micro-organisms. This is also shown by plates taken from the Apothecary's Shop of the same hospital during a time when the patients collect to obtain their medicines; here the air is laden with bacteria.

If you desire a further example, you will find it in plates prepared in the Smithfield meat-market. After a minute's exposure already they are covered with colonies; and we cannot wonder at this, if we remember how active the life there is, and how much organic matter is carried about.

In foggy or misty weather, when the air is quiet, the number of organisms is greatly reduced. It requires, therefore, but little reflection to recognise that, under ordinary conditions, the air which we breathe contains numerous bacteria: we live in a world which is not sterile, and, therefore, unless there exist special preventive measures, those body cavities which are in direct communication with the outer world must also contain bacteria. The mouth, the alimentary and respiratory tracts, and the pores of our skin are all in direct communication with space outside us, in fact, from the bacteriological point of view they represent simply the outer world.

We may, therefore, expect that the organisms which exist outside, in part at least, also find their way into these body spaces or cavities, even if they were not carried into the mouth with our food, or into the nose by the process of respiration. We cannot possibly prevent the bacteria from entering the mouth, even if we refused any but sterilised food. This is an important point to remember, because it proves the impossibility of excluding bacteria from the digestive tract. Saliva always contains them, often in great numbers; and as saliva is constantly swallowed, they must find their way into the stomach. But to return to the bacteria which we breathe. The air passages, *i.e.* the nose, larynx, trachea, bronchi, and their ramifications, and the alveoli or air spaces of the lungs contain bacteria. In normal respiration the inspired air enters the nose, but the anatomical structure of the latter is such as to act as a bacterial filter, imperfect no doubt, but still capable of retaining from three-fourths to four-fifths of the bacteria of the inspired air. Therefore, although large numbers of bacteria find their way into the nasal cavities, the true mucous membrane of the nose is surprisingly poor in bacteria; and this to some extent is due to filtration, and to the fact that healthy nasal mucus possesses considerable bactericidal or disinfecting power. If, however, the nasal mucous membrane is diseased, and it is frequently diseased in this country, large numbers of organisms may be found. The nose, therefore, is an important bacterial filter, and it follows that breathing through the nose is the best method which the body possesses for the purification of the air which we breathe. When we are forced to breathe through the mouth, bacteria are readily inhaled into the larynx. The latter, as well as the trachea, bronchi, and lungs in man always contain bacteria, because the nose is a very imperfect filter which often gets out of order, and also because the respiratory tract is in direct communication with the outer world. It is stated that the trachea, bronchi, and lungs of animals (rabbits) are almost free from bacteria; it is certainly not so in man.

The air which we breathe contains both organisms which are capable of producing disease, and organisms which are harmless. The latter are far more numerous; still pathogenic organisms, *i.e.* disease-producing organisms, do float about in the air, and may then be inhaled. The organisms which we find in the nose, mouth, larynx, and lung include some undoubtedly pathogenic forms, as for instance the micro-organisms of pneumonia, suppuration, &c. These exist in space around us, and therefore, unless they are destroyed in the respiratory passages, they must find their way into the cavities of the body which are in direct communication with the outer world; and thus we see that virulent organisms may enter the body and remain there without causing any lesions, for although we frequently inhale pathogenic organisms we do not inhale the diseases which they are capable of producing. The bacteria enter the body, but not its tissues; they thrive in the secretions and on the mucous membranes lining the various cavities of the body. But that only means that they are practically still outside the body proper. It is a common error to say that because an organism is found inside some space or cavity of the human body, that therefore it lives in the tissues or in the body. As I said before, all the cavities and spaces in direct communication with the outer world are the outer world, and we may expect in them the same organisms as occur in the outer world. The resistance of our tissues in health, and the absence of predisposing influences prevent the pathogenic organisms present from doing more than leading a harmless or saprophytic existence; but if for some reason or another they actually enter or irritate the tissues, the most serious forms of disease may appear, as for instance pneumonia. Many of us carry the organism of this disease about in our mouths, bronchioles or alveoli, although we remain perfectly healthy; pneumonia, however, frequently appears after a drenching or a chill. The coccus of pneumonia, which lay harmlessly on the mucous membrane, now assumes a virulent character, invades the lung tissues, and in some cases even the circulation. The bacillus of tuberculosis in rare cases has also been found in the nasal mucous membrane of individuals attending on consumptives; it did, however, no harm so long as it was outside the tissues on the mucous membrane, *i.e.* in the outer world whence it had come.

Anyhow, we must recognise that since, under ordinary conditions, we live amongst bacteria and decomposing matter, we must be inhaling large numbers of bacteria into our nose, mouth, larynx, trachea, bronchi and lungs; and that since pathogenic bacteria from time to time occur in dust, these also must find their way into those spaces and tracts. But we need not feel alarmed and insist on a sterile supply of air, because the danger of aerial infection is but slight, and because the survivors amongst the inhaled micro-organisms will remain harmless, unless the system is weakened or rudely disturbed by some interference. It is, however, well to remember that our respiratory passages may, and generally, perhaps, do contain numerous germs capable of producing disease and death, and that these germs may lie dormant there for a long time, ready under provocation to do their worst.

There is one other organism I wish to single out, because I shall have much to say about it subsequently, that is the *Bacterium coli commune*. This organism I have always found in saliva and in sputum, on the tonsils and on the pharynx. It is an ubiquitous organism outside the human body, and therefore occurs in the body spaces and, especially, in the intestines which are continuous with the outer world; and it would be surprising if it did not.

We may here conveniently consider the flora of the mouth and pharynx. Whatever micro-organisms are present in the mouth must have got there from the air or the food. At a particular moment there may be an enormous number of organisms present, but many of them are merely temporary visitors; they either die because they do not find suitable conditions, or they are passed on into the stomach and intestines.

The mouth is not guarded by a filter like the nose, but to a slight extent at least the saliva possesses disinfectant properties. The oral cavity is, however, never free from microbes, and some of them belong to highly pathogenic species, as *e.g.* the coccus of pneumonia, several forms of pus producing micro-organisms; and the diphtheria bacillus has occasionally been detected in the mouth or on the tonsils without there having been any history of direct contact with diphtheria cases.

These organisms may lead a saprophytic existence, and may remain harmless for a long time, till for some reason or another they are awakened to a life of virulent activity. Mr. Stephens and I have frequently found bacilli resembling the diphtheria bacillus in the dust, and though some of them are certainly not true diphtheria bacilli, others must be regarded with suspicion. Personally, after prolonged observations which I have carried on with Mr. Stephens at St. Bartholomew's Hospital, I incline towards the view that the diphtheria bacillus is more widely distributed in space than is generally believed, and that in a harmless or saprophytic condition it may be inhaled and fix itself upon the tonsils.

We have found in the air and on the surface of the body several varieties of bacilli, morphologically identical with the diphtheria bacillus. These are generally called pseudo-diphtheria bacilli. They are widely distributed. Some of them are so different in their biological characters from the diphtheria bacillus that they may be put on one side; others, however, so closely resemble it that they cannot be treated with the same contempt. Some observers feel a peculiar satisfaction in hiding themselves behind the security of the pseudo-diphtheria bacillus, which is an undefined quantity, including many varieties of forms. No one nowadays ventures to define the cholera germ; there are too many varieties of it. We believe that caution is advisable in the diagnosis of the diphtheria bacillus. We have come to the conclusion that when a bacillus is morphologically identical in appearance with the diphtheria bacillus, and in its biological characters closely resembles the conventional type of the diphtheria bacillus, he must be a bold man who ventures to say off-hand that this bacillus is or is not a diphtheria bacillus. We know of no test-tube reaction or animal experiment which will always decide it. We believe that the diphtheria bacillus is found in nature as a saprophyte, and that under special conditions it becomes pathogenic, and then diphtheria results. We see once more, that in the mouth also pathogenic organisms may enjoy a harmless or non-pathogenic existence, until conditions arise which alter their character and render them virulent.

We shall now pass on to a consideration of the bacteria which we eat and drink.

That severe gastric and enteric lesions and derangements, often accompanied by the most severe symptoms, and occasionally followed even by death, are only too frequently the result of consuming unsound food, cannot be questioned; and from the hygienic standpoint we must insist upon the sale of proper and sound food, and upon a careful preparation of food. "Food poisoning" may be due :—

(1) To irritation, the food being good in itself, but indigestible or altogether unsuitable.

(2) To bacterial infection; or

(3) To intoxication with poisons elaborated in the food.

(4) To intoxication by poisons purposely or accidentally added to the food.

Unfortunately, if we except the last cause of "food-poisoning," we have no sure tests which we can readily apply to gain information whether disease lurks in a tempting dish. We generally raise the cry of "death in the pot" after the mischief is done, and as a rule we do not get much further. In a free and easy manner the analyst and the medical officer of health speak of ptomaines and toxines which they generally fail to detect, or it is stated that an appallingly large number of microbes have been found in the fatal dish—and this is often considered sufficient evidence to explain the distressing symptoms which ensued.

The first point which I wish to make clear—or you may say to obscure—is the value of the quantitative bacteriological examination in cases of food-poisoning.

In many reports we read that an unusually large nnmber of bacteria were found, and that amongst these were various forms of the *Bacterium coli commune* or of *Proteus*. Now all such reports are somewhat unsatisfactory, unless we also know more of the circumstances under which the food was prepared or preserved.

First, as to numbers: what do they signify? Because we find 500,000 to a million, or even innumerable micro-organisms in a c.c. of fluid or in a minute particle of solid, can we, therefore, always say, in the absence of other evidence, that as food such articles are unsound, and that such numbers account for the symptoms observed? I think not, because I can quote figures which prove that persons who never suffer or have suffered from food-poisoning habitually ingest enormous quantities of bacteria without any evil accruing therefrom.

(1) *Milk* is constantly consumed by many individuals without harm. Now the best samples of milk that I ever obtained in London contained 250,000 micro-organisms per c.c.; generally we find 1 to 2½ millions per c.c., and if we let it stand at the ordinary temperature of the room these numbers may increase 20 to 1000-fold. Yet such milk is generally harmless, and we are not justified in condemning it on account of the large number of germs present. It is impossible to obtain milk free from bacteria, even if the cows were to be milked in a modern operating theatre, because the ducts in the teats always contain micro-organisms, which are washed into vessels, and there quickly multiply, and during the necessary exposure which must follow, more organisms find access to the milk. Mr. Parfitt has recently made some careful examinations of the bacteria present in London milk in my laboratory, and has found that 1 c.c. of milk contained 1,250,000 microbes, of which 303,000 were capable of growing at the temperature of the human body. I would, therefore, not undertake to condemn milk unconditionally, because 1 c.c. of it contained 500,000 to one million germs, and would hesitate to do so if it contained two, or even twenty, millions. Numbers here are not a true criterion; hundreds and thousands of people consume milk teeming with bacteria. I do not say that there is no danger in milk, for we know that tuberculosis, enteritis, diphtheria, and scarlet or typhoid fever have often been traced to milk; nor do I mean to say that the process of collecting and dealing with the milk could not be improved. These points are beyond our present argument. All I wish to show is that most of us consume habitually a large number of organisms without feeling any the worse for it. I do not recommend a bacterial diet, but I merely state the fact that we consume an enormous quantity of bacteria.

I know very well that milk is a frequent cause of enteritis in children, especially during the hot summer months, and this affection, which destroys the lives of many infants, is undoubtedly frequently due to bacteria present in the milk. Prof. Flügge's experiments have practically settled this point, and we must agree that under certain conditions a considerable accumulation of bacteria in the alimentary tract can hardly be a matter of indifference. It is, however, difficult to say what the limit is, beyond which the ingestion of micro-organisms becomes dangerous; and again it is possible, nay probable, that in many cases, for some reason or another, conditions arise which allow organisms existing in the gut, such as the *B. coli*, to proliferate at a great rate, and thus to produce most serious symptoms and intoxications. It is right and proper to avoid all dangers and risks by collecting and preparing food properly, by cooking it sufficiently, and by consuming no food that has been kept too long; but it is equally right and proper to remember that some articles of food are not only consumed, but also relished, which are known to contain enormous numbers of micro-organisms. We cannot make our lives miserable by refusing all but sterilised food; and I wish to point out to you that some articles of food which we particularly enjoy are teeming with bacteria, and for all that are not to be condemned. The question is, how did the organisms find their way into the food, *i.e.* what are the causes and circumstances of the contamination?

We are everywhere surrounded by danger, so far as bacterial infections are concerned. A slight scratch or a fall on the ground may be the cause of lock-jaw or tetanus. Are we, therefore, to give up all forms of exercise, such as football and bicycling? The friendly services of the bacteria outweigh the injuries which they inflict upon us, and I believe that just as in the world around us they do us many a good turn, so also in the world within us do they assist us. Possibly we could get on without them, but we do not know yet whether we could get on better without them than with them. Let us fight our foes, such as the organisms of typhoid fever and cholera; but this can be done with coolness and common-sense, and insistence on cleanliness and ordinary precautions.

(2) All *cold meat* contains numbers of organisms enough to frighten timid people. These are most numerous on the outside of the meat, but the interior is by no means free from them. I have frequently examined cold meat, and a single platinum loop often carries away innumerable germs from the superficial parts, and yet, as a rule, no ill-results ensue from the consumption of cold meat as ordinarily prepared. It is the custom to declare with disgust the legions of micro-organisms found in potted meat or in cold meat-pies, suspected as the cause of food-poisoning, and yet we find that potted meat and sandwiches bought at the most fashionable restaurants of London possess a flora which almost rivals the most virulent potted meat or veal-pie, and which, if numbers were an absolute test, should prostrate any one partaking of them. An error which is often committed, is that articles of food which bear the stamp of respectability, and which the better class consume, are not examined, so that we remain ignorant as to the numbers of organisms ingested with food acknowledged to be sound. I have recently examined the sandwiches offered for sale at one of the best-known London restaurants, and I find that less than a millionth part of a sandwich examined generally contained innumerable micro-organisms. I have myself eaten four to six sandwiches at that restaurant every day for the last twelve months or so that I spent in town, and live to tell the tale, nor have I ever heard of any one coming to grief from the effects of those sandwiches. Similarly potted meat, bought at the best sources, contains an extremely large number of micro-organisms, both aerobic and anaerobic.

(3) If we fix our attention upon the food of those who care for "good things," we find that *oysters* and cold *game* are also thoroughly impregnated with bacteria, yet, in spite of a few accidents, and in spite of the aspersions cast upon oysters, no one, I think, would venture to declare these articles to be invariably unsound food. Oysters are consumed by thousands of persons without bad effects, and they are often given to debilitated patients. We cannot, therefore, appeal to numbers as an absolute standard of good and bad food. However, we must insist upon this, that the oysters be cultivated and kept under conditions which exclude sewage contamination and filth. The layings should not be subjected to anything approaching risk of infection. Sewage always contains large numbers of *B. coli commune*; therefore, oysters, known to be fattened in sewage-polluted beds, which contain numerous *B. coli commune*, cannot possibly be said to be free from sewage contamination, if they have been properly and ably examined. If we are aware that direct contamination with human excreta has been avoided, we need not be alarmed at the presence of what might appear to be a large number of bacteria in oysters, so long as the latter are fresh. No one, after reading Dr. Thorne Thorne's masterly introduction to the recent Local Government Board Report on oyster culture in relation to disease, can doubt that the oyster may be the cause of disease, and that this danger can be obviated by removing the chances of sewage pollution. The chief danger arises from the possible presence of the typhoid bacillus, or the vibrio of Asiatic cholera. Their presence we must fear, but to restore a little confidence in the abused mollusc, I will quote some of Dr. Thorne Thorne's own words: "Only a few of the layings, fattening beds, or storage ponds round our coast can be regarded as theoretically free from every possible chance of sewage pollution. But, as regards the majority of them, any such polluting matter becomes mixed with so vast a bulk of water that it is difficult to see how the layings can be subjected to anything approaching substantial risk or deleterious influence." Still, as the reports show, there are exceptions to this comforting rule, and this should not be.

(4) What I have said about bacteria in normal food will become still clearer if I quote a few figures obtained by Mr. Stephens, when working in my laboratory on the bacteriology of *ice creams*. It has become the custom of using strong expressions against the ice creams sold by the Italian street vendor. It is indeed disgusting to see the same grimy glass used by a row of dirty boys, it being periodically washed in filthy water and wiped with an equally filthy rag; but in many quarters these ice creams have been condemned on account of their rich flora. Now I may remind ladies fond of ices, that the ices bought at the fashionable confectioners in London, as a rule contain as many bacteria as, if not a larger number than, the Italian's ice creams, on which they would look with disgust, if they regard them at all.

In several samples of street-ices Mr. Stephens found from 2 to 5 millions of bacteria per c.c., while strawberry ice creams bought at well-known West End confectioners at times contained from 10 to 14 million germs per c.c. The average number for the two kinds of ices was 7 millions per c.c.

If street-ices are to be condemned therefore—and there are many reasons why they must be condemned—we are not justified in condemning them on account of the number of bacteria contained in them, for in this respect they are no worse than the best ices sold in the West End of London, which afford great and generally harmless pleasure to many; but we must condemn them on account of the circumstances under which the bacteria have found their way into the Italian ice creams.

I could multiply instances to prove that most of us consume enormous numbers of bacteria. I have examined cakes and many other delicacies, and must come to the conclusion that the better-class people ingest as many, if not more, bacteria than those who from poverty are tempted to procure cheap and stale food. I must, however, content myself with the above statements, which prove the difficulty of deciding from a purely quantitative bacteriological examination of food articles whether, other things being absent, we are justified to express a categorical opinion as to their quality, safety, or nutrient value. In examining drinking water, the number of bacteria present in 1 c.c. is no doubt a measure of the adequacy of the filters, but one may wonder why 100 germs per c.c. should generally be considered the maximum number of bacteria which good potable water is allowed to contain. This or any other number absolutely measures the quality of the filter, but not the safety of the water.

We must now pass on to the second point, *i.e.* the species of micro-organisms present in sound food. Here again we find the results of bacteriological examination often unsatisfactory. We have but few, if any, organisms, so far as our present knowledge reaches, which are absolutely characteristic of unsound food, and which are invariably associated with it. In ordinary food I have always found numerous pathogenic or suspected organisms. The *B. coli commune*, *Proteus* forms, *staphylococci*, *streptococci*, organisms resembling the diphtheria bacillus, they may all be found in food which is considered to be above suspicion as well as in food which, by a process of exclusion, reasonably or unreasonably has laid itself open to doubt as to its integrity. I have frequently examined meat, suspected and unsuspected, and feel convinced of this, that in most cases from a qualitative examination we can only proceed to argue with caution, unless we succeed in separating the bacillus of tuberculosis, of anthrax, or of typhoid fever, the vibrio of Asiatic cholera, or probably one or other bacillus of enteritis. Various forms of *B. coli commune* and various forms of *Proteus* are common in articles of food, and were separated often in numbers in many of the sandwiches and other food articles examined. When they have been found in suspected articles in large numbers, they have frequently been considered as being adequately confirmatory of the suspicions aroused by the circumstances of the case. They are certainly evidence of staleness, and may become condemnatory evidence. For instance, water rich in *B. coli* derived from a river into which sewage flows, or into which excreta are drained, must be condemned, because this is clear evidence of sewage or fæcal contamination and of incomplete filtration. It has been thought that food containing large numbers of the *Proteus vulgaris* cannot be eaten with impunity. That is true in some and it may be in many cases, and is a good *post hoc* argument, but it cannot be made an absolute standard. In many sandwiches examined I have found large numbers of *Proteus*, and yet they proved harmless. This organism *per se* does not justify a verdict against the food. In milk the *Proteus* is extremely common, in most samples, at least, examined and consumed by myself without bad results. Now a writer in the *British Medical Journal* of 1895, having made the same observation, argues thus:—"Forms of *Proteus* are found in putrefying organic matter of all descriptions, and their distribution is wide. Their presence in milk must mean one of two things, either direct contamination with putrefying matter, or needless exposure to an atmosphere containing particles of decomposing matter." Thus this observer writes. *Proteus* is so common in food, because it is found everywhere in dust, and bacteriologically speaking all dust-laden air must contain particles of decomposing matter; hence the presence of *Proteus* may not mean more than ordinary exposure, not even needless exposure. It is difficult to see how one is to avoid the *Proteus*. Matter decomposes because the putrefying germs are present everywhere in dust, and putrefied matter rising as dust increases the stock of such germs in the air; the vicious circle is at once established. It is difficult to say what number of *Proteus* bacilli in an otherwise sound article of food would signify danger, and the value of such statement depends on the experience of the observer and on the circumstances of the case. But as far as mere qualitative evidence goes, viewed from the bacteriological standpoint, we all live amongst particles of decomposing matter. Should we get almost pure cultures of *Proteus* or *B. coli* and these forms present in large numbers, matters are easy enough—such food must be condemned.

Let us now turn to the *Bacterium coli*. Water has been condemned because it contained this organism in small or large numbers, and the writer quoted above asserted that "the colon bacillus, if found in potable water, is usually taken as diagnostic of sewage contamination," and "its frequent presence in milk he derives from the soiled cow and its surroundings, and he regards it as *par excellence* diagnostic of fæcal contamination." Many writers believe that water which contains this microbe at all, in however small numbers, has in all probability been polluted with excremental matter, and they regard this bacillus by itself as typical and specific of fæcal matter.

Now I consider that the *B. coli*, in its various forms, is a rather abused organism. With Mr. Stephens I have worked at this organism since the beginning of 1894, and have separated it wherever I came across it. It is our experience that it occurs in some form or another almost anywhere and everywhere: in the air, in the soil, in the water, in dust, of course in varying and variable quantities. We have found it in the secretions of the body where direct intestinal contamination could be excluded. It occurs in normal saliva, in expectoration, whether of health or disease, not occasionally, but practically always. In diphtheritic membranes, in abscesses, in the skin—everywhere it is. Fluids and solids exposed to air contain it; nothing can avoid it. On the surface of meat, even frozen mutton, on bread, fruit—everywhere it may be found. A few hours after birth it has been found in the intestinal tract of infants. We, therefore, have come to the conclusion that the *B. coli* is present in the intestines, because it is ubiquitous outside the animal body, and not that its presence anywhere and in any number outside the digestive tract necessarily signifies direct filth contamination. No doubt animal excreta assist in keeping up its supply, but it seems to me that simply because this bacterium occurs somewhere or other, to speak of direct filth contamination without other existing evidence is not quite logical. Of course it may be said that since filth forms a great source of this bacterium, and since the alimentary tracts, so to speak, envelops the earth, that therefore the presence of the *B. coli commune* does prove such contamination; but then it comes to this, that from a bacteriological standpoint we live and breathe in decomposing matter. I therefore doubt whether we have any right to condemn apparently sound water or food which contains the *B. coli commune* on the assumption that it has been soiled unless we have real or circumstantial evidence of such soiling. If water contains a large number of *B. coli commune*, we may have to condemn it on the score of being insufficiently filtered if the source of such drinking-water contains the *B. coli commune;* but in the absence of other evidence we cannot always do that. The bacillus fluorescence is almost constantly found wherever the *B. coli* occurs, yet no one would regard its presence in water, even in large numbers, as absolute evidence of direct filth contamination Yet the above observer concluded that the presence of the bacillus fluorescence in milk may be taken as presumptive evidence of added water: this is a *reductio ad absurdum*. Time forbids to say any more about the *B. coli commune*, and I am not here to discuss it.

I know of few organisms which are so indifferent with regard to the medium on or in which they are grown; aerobiosis or anaerobiosis, high or low temperatures, acid or alkaline reactions, light or darkness do not affect the *Bacteria coli* group to any marked degree. At the same time they are chemically extremely active organisms, and therefore their normal presence in the alimentary tract can hardly be of physiological indifference to us and animals. I incline to the belief that their influence in disease is secondary rather than primary, but I shall not discuss this point here.

Now, when we are dealing with organisms which are capable of growing and acting on dead as well as on living tissues, which are furthermore capable of great and varied chemical activity, and also resist external influences extremely well, and readily vary under such influences, it seems to me that an important point may be raised. If there be anything in adaptation, then I think the animal body must have adapted itself as much to the *Bacteria coli* group, as the latter, no doubt, has adapted itself to the animal body. The two organisms, viz. the *Bacterium coli* and the animal body must be well balanced; if the balance is disturbed, one of them must go down. Symbiosis, whether obligatory or facultative, is a problem which has hardly been touched upon as existing between man and low forms of germs. We know that plants make use of micro-organisms, and that vegetation is immensely assisted by nitrifying organisms. Under absolutely sterile conditions of growth a plant thrives badly. Experiments and observations are needed to show how animals would thrive on sterile food and in sterile surroundings. Pasteur, in 1885, expressed the opinion that they would do badly under such conditions. Nuttall and Thierfelder have shown that a guinea-pig brought aseptically into this world may be kept in good condition under sterile surroundings for 8 to 14 days, and from their experiments they argue that the presence of bacteria in the intestinal tract is not necessary to life. The obvious criticism is that a week or two for such experiments is too short a period, and that it would require observations carried on for months before it could be definitely stated whether or no bacteria are necessary not for life but for perfect development.

Fermi seems to incline towards a belief in a form of symbiosis existing between the *B. coli* group and the intestinal mucosa. There are observations which tend to show that lower forms of animal life do not grow or thrive well on sterile food. It seems possible from studying Neumeister's work on physiological chemistry, that some forms of bacteria—not necessarily the *B. coli commune*—are of use in assisting fermentative processes, and in aiding in the resorption and absorption of products of digestion, and it is certain that as putrefactive organisms they do good. Nor is it impossible that they are capable of splitting up certain toxic substances, thus rendering them harmless. The question of adaptation of the body to bacteria is well worthy of extended study; but while it is still a matter of speculation, it is safer to dismiss it with this brief allusion.

Taking a summary review of the points mentioned, we have seen that under ordinary conditions sound food often contains large quantities of bacteria, so that we habitually consume numberless micro-organisms. Further, the qualitative examination shows that we are habitually consuming such forms as the *B. coli commune* and *Proteus*. It is well that we should know the flora of apparently good food, and become familiarised with the idea, alarming to many, no doubt, that many articles of food daily consumed contain bacteria, some of which are described by bacteriologists as the typical organisms of the intestinal contents and of decomposing matter.

I do not wish to be misunderstood. I am not advocating the view that good food should be particularly rich in bacteria. All possible chance of direct fæcal, sewage, or other contamination should be, and must be, carefully avoided. On the other hand, we must not introduce a fictitious standard, and simply put on one side physiological facts and common-sense experience. Similarly we must pause before we give certain bacteria an absolutely specific significance which they possibly do not deserve.

The *B. coli commune* by itself does not prove sewage or fæcal pollution; it may and often does point to it, under certain conditions which Dr. Klein has recently defined, but it cannot unconditionally prove it. Again, its importance as the cause of enteritis must not be exaggerated. Thousands of *coli* bacilli are periodically taken in with the food, and they pass into an alimentary canal already full of these bacilli. This is a point worthy of consideration. True in an enteritis the *B. coli* may be found in pure culture in the dejecta, possessed of virulent properties when tested on the animal. This merely proves one of two things: if the *Bacterium coli* is the cause of the lesion then for some reason or another it must have been transformed from a harmless saprophyte into an irritant pathogenic organism; but it has not yet been shown that this organism is the cause of such a lesion, and therefore its abundant presence in such a lesion may be merely a concomitant phenomenon. The exact position of this extraordinary organism, or rather group of organisms, has not yet been exactly defined. Many observers may not agree with me; my own opinions are, however, based upon my personal acquaintance with the *Bacterium coli* and its varieties. It is of value in water or food examination, not because it is absolutely specific of bad or polluted food, but because it is easily recognised, and therefore its source can often be traced. Food or water exposed to the danger of sewage or fæcal contamination, as for instance Thames water, containing a certain percentage of *B. coli commune*, cannot be said to be freed from all pollution. Further we cannot go.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Head Masters' Conference at Rugby last week passed the following resolution unanimously:—"That the Conference deplores the time wasted in teaching boys the present system of weights and measures, and would welcome the introduction of a more rational system."

AMONG the French Universities which, in accordance with the new Act, will at the end of next year be permitted to dispose of the money accruing from students' fees, &c., the richest will be that of Lyons, which will thus have an annual income of over 5000*l.* According to the Paris correspondent of the *Chemist and Druggist*, schemes are already on foot for important educational extension in the capital of the centre. The Lyons Faculty of Medicine and Pharmacy, as well as the Faculty of Sciences, will probably be enlarged, and new laboratories built or the present ones extended. But the most important project is the construction of a Chemical Institute, in which will be re-united the various chemistry services of the two above-named faculties; and the already flourishing School of Commercial and Agricultural Chemistry will be also installed in this new building. The erection of this Institute will, it is hoped, be commenced next spring, and the cost is calculated at 60,000*l.*, but the municipality will give the site, valued at 16,000*l.*, and possibly other aid. The department has voted 2000*l.*, and the State, it is hoped, will contribute over 25,000*l.* The head of the University states that, while laboratory research will not be neglected, the University will seek "to incorporate itself more and more with the industrial city" and "develop the technical instruction that may serve the commercial and manufacturing interests of a great city of half a million souls."

SCIENTIFIC SERIALS.

Wiedemann's Annalen der Physik und Chemie, No. 12.—Directed electric surface conductivity, E. Braun. Continuous transition of electric properties in the separating surface of solid and liquid bodies.—Conduction of electrified air. Magnetic currents. By the same author. Crystals have a different electric conductivity in different directions. This was proved by Wiedemann by dusting lycopodium powder on a cleavage surface and sending a spark from a wire into it. An elliptic area was cleared, with axes in a ratio varying from 1 : 2 to 1 : 3. The author obtained different surface conductivities with a steady current, through a layer of condensed moisture. The effect vanished when the thickness of the layer exceeded 50 $\mu\mu$. A steady transition from the polarisation properties of a solid to those of a fluid body may be traced in the surface layer.—Polarisation phenomena in vacuum tubes, by C. A. Mebius. When the current through a gas increases, the rate of fall of potential at the kathode increases more rapidly than at the anode. When secondary terminals are introduced, so as to give a transverse current, the rate of fall of potential at these decreases with an increase of the main current, when a current of a certain strength is sent through the secondary terminals.—On the transition of carbon from the non-conducting to the conducting condition, by G. Brion. The conductivity of carbon depends upon the highest temperature to which it is exposed, the time since elapsed, and the present temperature. It is acquired very rapidly at temperatures between 800° and 1000° C. The conductivity decreases rapidly during the first few hours after heating, and then more slowly.—On electro-capillary light, by O. Schott. On sending the sparks from an induction coil through a capillary tube 0·05 mm. in diameter containing air at ordinary pressure, an intense light is observed in the tube. The latter soon gets roughened and blown out into spherical bulbs. Wider tubes gave a less intense light, and are less altered. Electrodes of various metals may be used with the same effect. In the spectroscope, the light shows a continuous spectrum crossed by bright lines, and dark lines along the spectrum which shift their position at every discharge.—Glow-worm light, by H. Muraoka. Natural glow-worm light behaves like ordinary light. But when it is filtered through cardboard or through copper plates, it shows the properties of X-rays or Becquerel's fluorescence rays. The intensity of the action of the glow-worm rays is intensified by the presence of the cardboard near the sensitive plate. They may be reflected, and probably also refracted and polarised. The author operated with 300 glow-worms at Kyoto, Japan, during the month of June, when thousands of them swarm about the neighbourhood.—An attempt to demonstrate the existence of electrodynamic solar radiation, by J. Wilsing and J. Scheiner. Owing to the absorption of the longer waves by the atmosphere, and the consequent necessity for an instrument of extreme delicacy, the change of contact resistance between two metals was used as a test. But no positive results were obtained.

Bollettino della Società Sismologica Italiana, vol. ii., 1896, N. 4.—Recent observations and results on the form and mode of propagation of seismic waves, by Dr. A. Cancani.—The seismic data of Liguria, with reference to their frequency and periodicity, by Dr. E. Oddone.—On the after-shocks of the great Japanese earthquake of 1854, by Prof. F. Omori.—Notices of earthquakes occurring in Italy during the year 1896, by Prof. L. Palazzo. This catalogue, a continuation of that formerly compiled by Dr. M. Baratta for the Central Meteorological and Geodynamic Office at Rome, contains accounts of all the shocks recorded from January 1 to June 14 The more important are those of Polesina on March 8, near Florence on April 15, in Asia Minor on April 16, and several earthquakes of unknown and distant origin on March 4, April 10, and May 2, 3, and 5.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 10.—"On Prof. Hermann's Theory of the Capillary Electrometer." By George J. Burch, M.A.

In reply to the claim of Hermann (*Archiv für die Ges. Physiologie*, vol. lxiii. p. 440), that his theory of the capillary electrometer received confirmation from the author's experimental results, the author stated that his own theory was completed before he saw Hermann's paper, that it was based upon a totally different hypothesis, and that the identity of Hermann's equation with his own is due simply to the fact that both are the mathematical expression of a movement which is dead beat. Hermann, adopting Lippmann's polarisation theory, had assumed the simplest conceivable relation between the rate of polarisation and the acting P.D., namely, that they are proportional to one another. The author's starting point was the fundamental fact that in the capillary electrometer a mechanical effect is produced by an electrical cause. Writing Q for the quantity of electricity, C for the constant of capillarity, P for polarisation, and W for the work done, the symbolical expression of the problem is—

$$f(Q_t, C_t, P_t) = \phi(W_t).$$

Hermann has passed over C and omitted to take W into account, confining himself to the theoretical relation between Q_t and P_t. But the term polarisation includes two phenomena, viz.:—

(*a*) That condition of the interface between two conductors, of which one at least is an electrolyte, in which the molecules are under a stress not greater than they are capable of supporting without chemical change.

(*b*) A deposit upon the surface of a solid, or in the contiguous liquid, of the products of actual electrolysis.

If one of the conductors is a solid, the inevitable local differences of condition or of composition enable actual electrolysis to take place even with a P.D. smaller than that proper to the chemical change implied. But if both conductors are liquid and perfectly pure, the stress is so far equalised that no electrolysis is possible until the E.M.F. reaches a certain value, more sharply defined in proportion as the materials are pure. The author holds that with differences of potential which do not reach this limit, the electromotive force is transmuted, without electrolysis, into mechanical force, and manifests itself as kinetic energy, until by the motion of the meniscus it becomes transformed into potential energy. The locus of transformation from electrical to mechanical force must clearly be the two